Viability, method and device for horticultural crops with brackish and marine water

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Abstract— *The method that humanity has adopted to hydrate and thus give life to the plants, imitating the model that was most visible, is the rain. However, the great secret to the contribution of nutrients to the vegetables, the irrigation itself, is on earth, in the groundwater layers and aquifers that hoard and administer the water, keeping every drop of rain and distributing the water through the basins, underground rivers, watering indirectly from the mountain to the sea. The key is in the different circulation velocities of the groundwater because of the nature of the substrates. However, agriculture has taken irrigation from above as we know it and has focused especially on drainage capacity. From this point of view, saline water is not beneficial for irrigated agriculture, but may be the only source of irrigation water in large arid regions, especially in developing countries, where the extreme scarcity of freshwater and the rapidly growing population require more water.*

When considering the possibility of watering with seawater without desalinating, always by means of capillarity systems, it is essential to take into consideration the different strata of soils, the distance to the groundwater, the composition of seawater, the capacity of drainage, chemical reactions of the soil with salts, etc. The modification of any of these parameters can produce effects of salinization, loss of humidity or desertification among others.

This study presents the accumulated experience through the joint collaboration between the Centre for Research in Security and food Control of the Polytechnic University of Catalonia (CRESCA) and the Aqua Maris Foundation in capillary irrigation and it proposes a system and device that allows the controlled development of different vegetal species using brackish and seawater.

Keywords— ***desertification, desalination, reuse, underground stream seawater.***

I. INTRODUCTION

The United Nations, within the framework of its sustainable development programme called Agenda 21, establishes that desertification is the degradation of land in arid, semi-arid and dry sub-humid areas resulting from various factors, including variations climatic and human activities.

Desertification affects about one-sixth of the world's population, 70 percent of all drylands, which represent 3.6 billion hectares, and a quarter of the world's total land surface.

The most obvious impact of desertification, in addition to widespread poverty, is the degradation of 3.3 billion hectares of the total grassland area, constituting 73% of grasslands with a low potential for human and animal load capacity; Decrease in soil fertility and structure in approximately 47 percent of dry areas that are rainfed, marginal farmland; and degradation of irrigated farmland (United Nations 1992).

The main causes of desertification are climate, erosion, ecological factors-the type of soil and ecosystem-and human action. Erosion is the prelude to desertification, because when the air and water drag the surface particles of the soil, it loses the fertile layer, and remains unprotected, being increasingly slow regeneration of the vegetation cover. Difficult-to-drain terrain, torrential rains or drought are other phenomena responsible for desertification.

But the most damaging factor, together with climate change, is human activity. Fires, indiscriminate logging, overexploitation of aquifers, intensive crops, with massive use of chemicals, and some forestry practices (forest or mountain cultivation) are some of the examples of human intervention. In the world there are more than a hundred countries with arid and semi-arid conditions. Africa is the continent most damaged by desertification; He is followed by Asia, Latin America and the Caribbean. Also, southern Europe and Spain (FAO 2000).

In counterpart, about 70% of the entire planet is covered by liquid water, being the most abundant resource in the surface layer of the earth. However, its distribution is very variable: in some regions it is very abundant, while in others it is scarce. However, the total amount of water on the planet does not change (Aparicio 1987) and moreover, about 97,5 % of this 70% of liquid water is saltwater.

Water exists in solid (ICE), liquid and gaseous (water vapor) form that can be observed in oceans, rivers, clouds, rain and other forms of precipitation in frequent changes of state. Thus, surface water evaporates water from clouds precipitate, rain seeps into ground and runs to the sea. The whole of processes involved in the circulation and conservation of water on the planet is called hydrological cycle or, more precisely, geohydrologic cycle (Pidwirny 2006).

Fresh water is a renewable resource, but it is also finite. Around the world there are many signs that human use of water exceeds sustainable levels. The depletion of groundwater, the low flow of rivers and the worsening of pollution levels are among the most obvious indicators of water stress (Postel 2000). Thus, for example, global demand for water has tripled approximately since the mid-twentieth century (McCully 1996).

The World Health Organization (WHO) considers that the adequate amount of water for human consumption (drinking, cooking, personal hygiene, and household cleaning) is 50 L/HAB-day. The necessary contribution to agriculture, industry and, of course, to the conservation of aquatic, fluvial and, in general, freshwater-dependent ecosystems must be added to these quantities. Considering these parameters, it is considered a minimum amount of 100 L/HAB-day. (Howard & Bartram 2003)

The destination applied to fresh water consumed varies greatly from one region to another on the planet, even within the same country. Generally, the high consumption of drinking water is given in rich countries and, within these, urban consumptions double to rural consumptions. At the global level, some 3,600 km3 of freshwater for human consumption are currently being extracted, that is, 1,600 liters/HAB-day, of which, approximately the half is not consumed (it evaporates, infiltrates to the soil or returns to some channel) and, of the other half, it is estimated that 65% is destined to agriculture, 25% to industry and only 10% to domestic consumption.

According to WHO, in 2010, 87% of the world's population, i.e. 5.9 billion people, had sources of potable water supply. On the contrary, almost 39% of the world's population, or more than 2.6 billion people, lacked improved sanitation services. Currently, more than 1.2 billion people consume water without health guarantees, which causes between 20,000 and 30,000 daily deaths and a large number of diseases (WHO & UNICEF 2017).

Water management aims to improve the quantity and quality of the water available. The ways to achieve this are: to regulate the use of surface water and groundwater, to develop alternative water sources, to rationalize their consumption, to control the supply of pollutants and to recover the initial conditions by means of purification processes. The objective of a good water state should be pursued in each watershed, so that the measures relating to surface water and groundwater belonging to the same ecological, hydrological and hydrogeological system are coordinated (Directive 2000/60/EC).

From this perspective, the reuse of purified water is an essential element of the natural water cycle and, in fact, it is envisaged as a measure to solve the problems of water scarcity.

Reuse is very valuable for agriculture, since it guarantees the resource continuously. Its application is a common practice in many areas, especially in the arid and semiarid regions. In this respect, in Spain, in December 2007 the Royal Decree 1620/2007 was promulgated, which established the permitted uses and the criteria of quality, of minimum frequency of sampling, of reference point for the analytical methods and of conformity (BOE December 8th 2007).

On the other hand, seawater is a concentrated solution of inorganic salts that serves as a habitat for countless living beings, with plankton being the most important volume of biomass, consisting mainly of algae (phytoplankton) and microscopic animals (zooplankton). The waters located on the continental shelf are generally greenish due to the presence of chlorophyll and other fito-pigments, and by some substances contributed by the soluble humus of terrestrial origin. It is by far the area of greatest richness and diversity in marine species (Custodio & Llamas 1983).

The composition of the sea water varies according to its origin or marine characteristics, being of higher concentration of salts in warm places with little renovation as in the Mediterranean, and smaller in semi-enclosed places with abundant continental contributions like the Baltic Sea (Grasshoff et al. 1999).

Given the high rates of pollution of rivers, reservoirs and groundwater, an important option is presented: desalination of seawater to obtain consumable water (Lechuga *et al.*, 2007).

As far as the demand for desalinated seawater is concerned, its demand has increased considerably in recent years. This is due, above all, to the serious shortage of water resources that is being suffered in various parts of the world. The three most important processes in the desalination of brackish or marine water are: Reverse Osmosis (RO), Multi-Effect distillation (MED) and instantaneous multi-stage Distillation (MSF) (Veza 2002).

In recent years, the idea that water management should be understood as an instrument in the service of an explicit territorial policy has been reinforced and that it is also supported by the growing demand for integration between water management and Sectoral policies (Del Moral 2009). From this perspective, this study proposes the direct use of seawater, without going through a process of previous desalination, as a fluid to be used in the irrigation of various types of cultivation. To this end, a set of experiences jointly carried out by CRESCA and the AquaMaris Foundation, aimed at demonstrating its viability in both outdoor and greenhouse crops, is collected.

II. MATERIAL AND METHODS

All the experiences that are related in this study have in common that seawater was circulated underground. In this way, by capillarity, seawater was dispersed through the corresponding solid substrate and roots of the selected plant species had access to the moisture and nutrients contained in this fluid as it can be seen in the explanatory diagram of Figure 1.

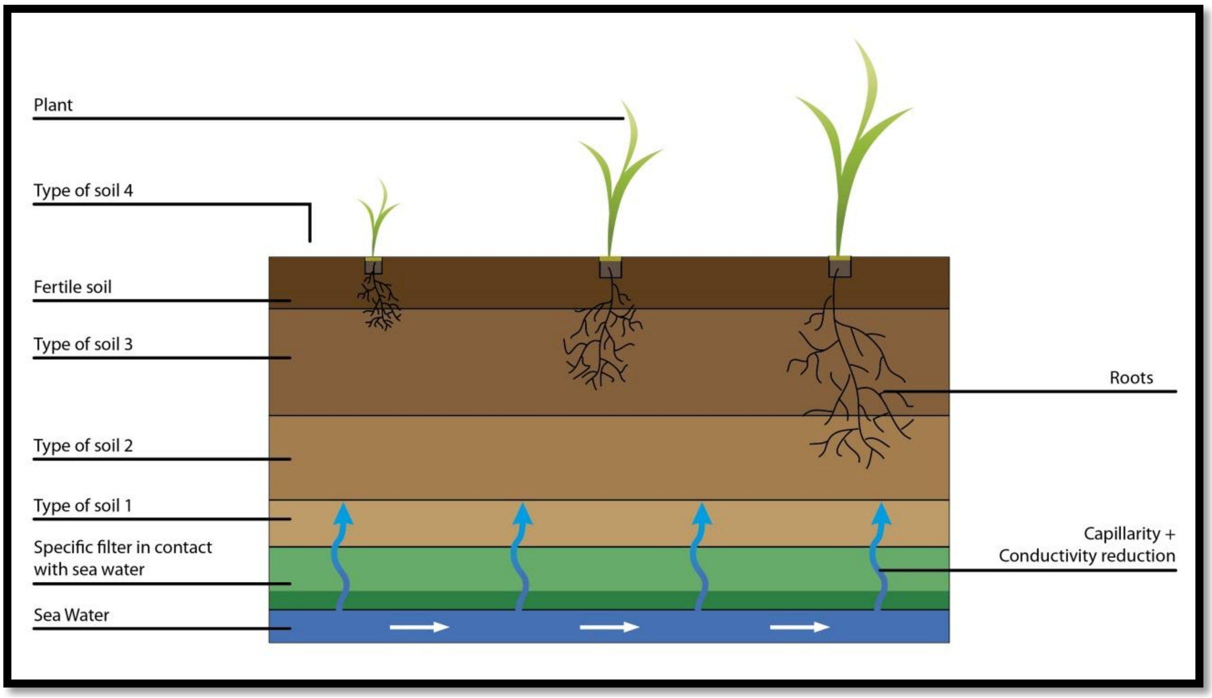


FIGURE 1. Supply of moisture and nutrients to the solid substrate by means of an underground stream of seawater

2.1 Background

In the facilities of the AquaMaris Foundation, a first experience was made to determine the correlation between the distance between the groundwater flow of brackish or marine water and the roots of the selected plant species (radish, lettuce, parsley, cabbage, chard, arugula, basil, endive or tomatoes, as well as an ornamental plant). To this end, a small garden of three levels was built. At the lower level, the different plant species were 40 cm from seawater; In the intermediate level at 80 cm and in the upper to 110 cm. Figure 2 shows schematically the construction work done to develop this experience.

FIGURE2. a) Scheme of the operation of the experimental garden of three levels (40/80/110cm regarding the seawater level b) Actual structure enabled in the AquaMaris Foundation

The type of terrain used in this experiment was a clay composition, with a high capacity for moisture retention and capillarity, but little drainage. In addition, a substrate was incorporated as a filter, consisting of a mixture of materials with very specific physicochemical characteristics, which allowed the passage of water to the upper layers and, simultaneously, was able to significantly reduce the conductivity of the water. This was intended to recover the soil in an easy way, without having to replace it.

Although this experience was subject to the rainfall regime of the Mediterranean basin, the viability of the use of seawater was demonstrated. What's more, a similar experience was designed and developed in the Atacama Desert, with satisfactory results (Gutierrez 2017).

The viability of the use of seawater as an underground supply of moisture and nutrients, in a second phase, was determined to delimit the conditions in which certain crops could be viable. For this purpose, four containers were enabled as shown in Figure 3.

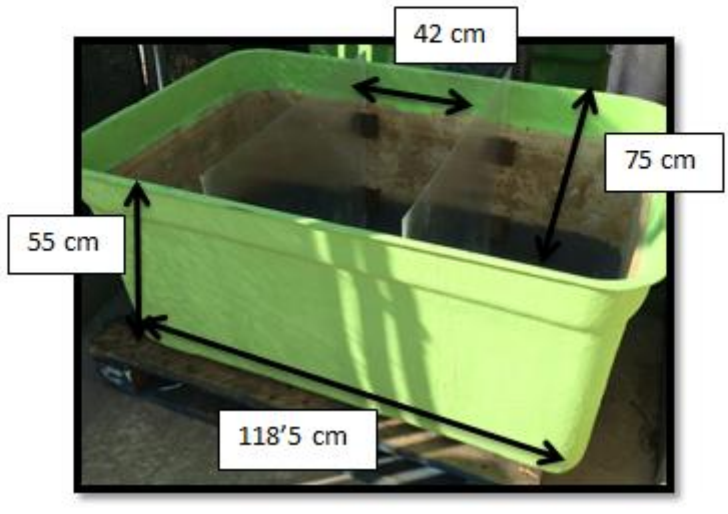


FIGURE 3. Form and measurements of the containers used

At the bottom of these containers a 3 cm thick air chamber was prepared which was subsequently used for the circulation of seawater. These four vessels were separated into two groups. The first of them was left to the mercy of the influence of the rain. On the contrary, the second was kept in guard.

In the two vessels of the first group, two types of substrates were used, one consisting of a mixture of sandstone enriched with compost (A) and the other based on clayey soil of low organic matter content (B).

Each container was subdivided into three zones. In each zone a layer of sandstone was deposited as a filter between the seawater and the corresponding substrate. The different thickness of this sandstone layer was 14 (A1, B1); 27.5 (A2, B2) and 41 (A3, B3) cm. The second layer was a mixture of sandstone and compost at 50%(v/v)and its thickness was adjusted to that of the sandstone layer, so that its thickness was limited leaving a space of 10 cm to the edge of the container. The selected vegetables were: chard, dandelions and tomato cherry and during the first two weeks were irrigated with freshwater (public network) to ensure their roots in the field.

Schematically, the distribution of the selected vegetables in each of these two containers is shown in Figure 4.

FIGURE 4. Distribution of tomatoes, dandelions and chards in containers

On the other hand, the other two containers were protected from the influence of the rain, so that the selected vegetables could only receive water either through the environmental humidity, or from the seawater deposited in the bottom of the vessel renewed periodically, except during the first two weeks, as in the previous case, were irrigated with fresh water, to ensure their roots in the ground.

On this occasion, the selected vegetables were lettuce and tomato cherry and the sandstone layer presented two levels, 25 and 75% of the useful height of the vessel, i.e 15.5 and 46.5 cm, respectively. The second layer, as in the previous experience, was the same mixture of sandstone and plant compost at 50% and its thickness reached up to 10 cm from the rim of the container. The two groups of recipients were allowed to evolve over a three-month period.

On both occasions, a control vessel was used to grow the selected plants with water from the public network. The composition of the land was compost plant 100%.During the growth period of the selected vegetables, the soil moisture and conductivity were monitored.

For the monitoring of the soil moisture, with the help of a spatula, a hole of about 20 cm of depth was made on the surface of the terrain. Once the hole was made, a sample of approximately 10 grams was taken. Later, with the help of a scale, an accurately known amount was weighed in a Petri dish and was introduced in a stove at 110 º C for a period of 24 hours. Then it was introduced into a desiccator to room temperature and weighed again. The percentage of soil moisture was determined from the weight loss.

In containers subject to the influence of rainfall, each time the soil moisture was determined, a sample should be taken in each of the three zones in which each vessel was divided (see Figure 4) and another, corresponding to the control vessel. In the second experience, it was only necessary to take two samples of each container and another one, corresponding to the control vessel.

The soil moisture and the conductivity were determined. To do so, the dry specimen from the previous test was introduced inside a bottle with a screw cap. Immediately, 80 mL of distilled water was added, and mechanical agitation was proceeding, with the help of a magnetic stirrer, for a period of 30 minutes. It was then left to rest for a period of 24 hours and the contents of the vial were filtered. The filtrate was used to determine conductivity by conductivity Jeulin JLC20.

In the containers to which the access to rain was restricted, a control was made of the evolution of the plants through the moisture content in the plant freshly harvested; The content of organic matter, obtained by calcinations and the pH of the Ashes.

The humidity was determined as the loss of weight of the newly harvested vegetable at a temperature of 110 ºC over a period of 24 hours. The organic matter content was determined as the weight loss of the dried vegetable at 110 ºC after being calcined at 470ºC for 4 hours.

The pH was determined in the fraction of soluble ashes, from previous calcination, by means of a Phmetry Thermo Scientic Orion 2 Star.

It was systematically preceded as follows: From each sample, two thirds of the ashes were treated with 100 mL of distilled water in a beaker of 200 mL and kept boiling for a period of 10 minutes. As they were allowed to cool, the sample was kept in agitation with the help of a magnetic stirrer. Once ambient temperature was reached, the contents of the beaker were filtered through a filter paper that had previously been thermally treated at 110 ºC until constant weight. The filtrate was collected and flushed in a 250 mL volumetric flask.

The viability of the growth achieved in this experiment induced to optimize the behaviour of the material layer in contact with the seawater, in order to regulate the migration of salts from the seawater to the substrate.

2.2 Optimization of the material in contact with seawater

The initial objective was to determine the height that, by capillary, would reach seawater in presence of different types of land. For this purpose, specimens made with plastic tubes, of constant diameter (57 ± 5 mm), were prepared and filled with the tested substrates. These tubes were introduced into containers where water height was predetermined, as shown in Figure 5.

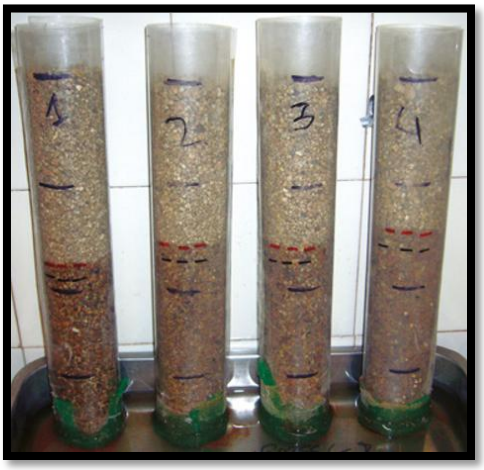


FIGURE 5. Behaviour of specimens with sandstone after four days in contact with seawater

The materials initially selected were: Sandstone of different particle size (coarse, medium and fine), beach sand and compost plant.

Table 1 shows the particle size of sandstone and beach sand, which had previously been dried at 110 ºC, until a constant weight was obtained.

TABLE 1
GRANULOMETRIC ANALYSIS OF SANDSTONE AND BEACH SAND

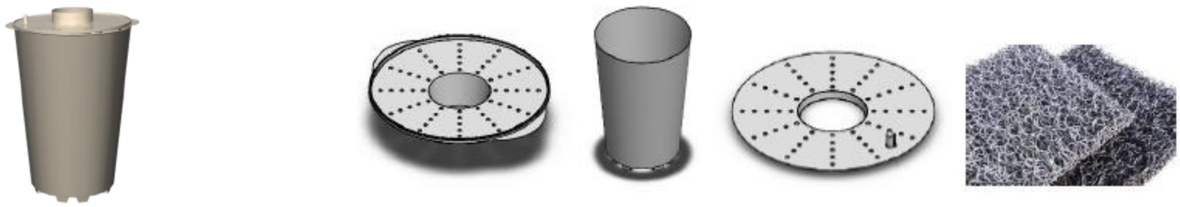
Size	% Thick sandstone	% Medium sandstone	% Thin sandstone	% Beach sand
>2mm	82,5	20,4	2,6	4,3
1-2mm	12,0	31,7	32,3	42,0
<1mm	5,5	34,4	65,6	51,1

In addition to determining the height at which the seawater reached the inside of the specimens, the value of the electrical conductivity was determined at different levels, once it was considered that the water had reached its maximum height. To this end, samples were taken of the substrate contained inside the specimen at different levels and dried at 110 ºC for 24 hours. From the dry material, aliquots of 10 grams were taken and each aliquot was introduced inside a container with a Hermetic seal where 100 mL of distilled water were added. Then, mechanical agitation was proceeded with the help of a magnetic stirrer for a period of 30 minutes. It was then left to rest for a period of 24 hours and the contents of the vial were filtered. The filtrate was used to determine conductivity by a conductivity Jeulin JLC20.

2.3 Tlaloc Device design

From the results obtained in the preceding section, the design of a container suitable for use in a greenhouse was proceeded. Under the name of Tlaloc (Aztec god of Rain and Earth), the device, shaped like a pot, was designed to optimize the function it should develop: to allow the use of seawater as a vehicle for the transport of moisture and nutrients, by capillarity, towards the substrate where the selected plant species are cultivated.

Figure 6 shows the external aspect as well as the various components. The Tlaloc device is composed of three plastic pieces, these are; The flowerpot, the lid and the ventilation system. A PVC curly vinyl grille is also required.



(a) **(b)**

FIGURE 6. a) External appearance of the Tláloc device b) Complementary components

Figure 7 shows an outline of how the Tlaloc device works. Conceived and designed to be used in a greenhouse, the lower supports are bored in order to allow the circulation of seawater that will contact the substrate selected for each type of crop. On the upper part is the cover that incorporates the condensation and ventilation system. In its central part it has a hole where the cylinder is inserted with the plant to be cultivated.

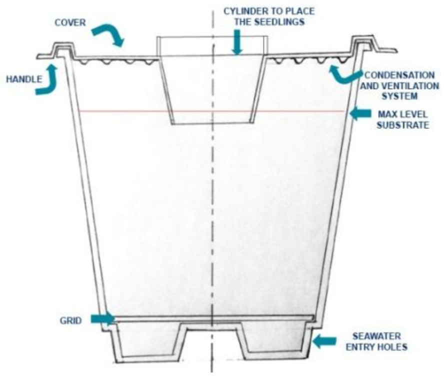


FIGURE 7. Diagram of the Tláloc device

2.4 Experiences with the Tlaloc device

The cultivation of Chard was followed (Beta vulgaris var. Cycle) inside a greenhouse. The plant, of 160 plants, was bought to the company Semilleros Rovira S.C. P located in Cabrera de Mar. Different experimental series were set up in which different experimental conditions were compared, especially the thickness and composition of the different substrates contained inside the 28x18 cm Tlaloc device. Sandstone was used (with a particle size greater than 2 mm), beach sand (with a particle size between 1-2 mm) and Floradur vegetal compost, with an electrical conductivity between 25-50 mS/cm and a pH between 5.5-7. This substrate contains an NPK fertilizer in proportions 18-10-20.

Four different treatments were used plus control. The variation of the treatments was the filter used and the height of this. The filters used were beach sand (A) and sandstone (S) and the filter heights were 6 cm (A1/S1) and 20 cm (A2/S2). The treatment used as a control (C) had only compost.

For each treatment 32 devices were used Tlaloc arranged in 4 trays and in rows of 8 devices per tray.

After 43 days it was collected and the analysis of the product was carried out, preserving a part to make the study of the conservation. To carry out the study of conservation were taken all the chard of the same treatment, were mixed and elaborated 15 trays of porexpan per treatment, of approximately 100g of weight, closed with paper film and were kept in refrigeration for 12 Days at 4 ± 1 ºC. The parameters evaluated were moisture, mineral matter, ascorbic acid, content in Na^+, K^+, Ca^{2+} and Mg^{2+}, colour and various plant measures such as weight, height and leaf amplitude.

The results showed that the conservation of the chard was similar between those irrigated with red water and those irrigated with seawater. In the case of chard irrigated with seawater, it was determined that the height of the filter (6 or 20 cm) was of greater importance than its composition (sand or sandstone) in parameters such as humidity and ascorbic acid.

Figure 8 shows a general view of the interior of the greenhouse after planting the whole chard and after 23 days.

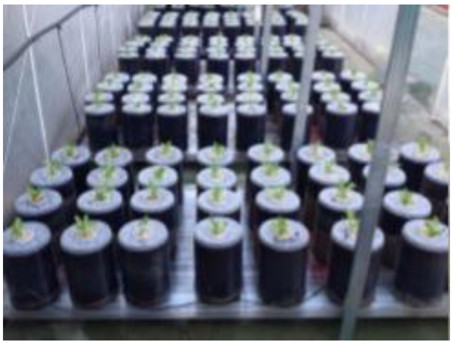


FIGURE 8. General view of the greenhouse a) freshly planted chard b) the same chard after 23 days.

The fresh weight was determined by weighing the whole of the chard collected in each test with an accuracy of ± 0, 1g. The result was expressed in g.

The humidity was determined by the Gravimetric method AOAC 931.04, weighing 50 ± 0,01g of fresh and cut sample, keeping it at 60 ºC, up to constant weight (48 h approximately) in a vacuum stove. The moisture content was calculated by weight difference and expressed as a percentage of water (%). The humidity was determined at the time of collection (day 0) and during the conservation process on days 2, 6, 8 and 12.

The colour of the chard leaves was determined using a KONICA MINOLTA CR-400 colorimeter with aperture size of 8mm and Illuminate D65. The different colour parameters that were determined from the coordinates in the CIELAB space were:

L *: luminosity, Degree of clarity where 0 = black and 100 = white.

A *: chromaticity, Green (-a) and red (+ a).

b *: Chromaticity, Blue (-b) and yellow (+ b).

From these parameters the corresponding colour index (IC) was determined, according to:

$IC = b^* \times 1000 / a^* \times L^*$

The ascorbic acid was determined by the method AOAC 967.21, based on the redox volumetry which has as reagent titrating the DCPI (2.6-diclorofenolindoenol). Before the volumetry, a standardization of the DCPI was performed with a solution of ascorbic acid of known concentration (0.1 g/L). The results were expressed in mg of ascorbic acid/100 g of fresh specimen.

The AOAC 971.33 method was followed for the determination of the mineral matter. Starting from the dry matter, 1.5 ± 0 were weighed, 0001g in an analytical balance Scaltex SBC 33 and calcined at 470 ºC during 4h until obtaining white ashes. The residue obtained was weighed to obtain the% of mineral matter (M.M.) and the% of organic matter (M.O.). Subsequently, the ashes were dissolved in 15 mL of hot 3M nitric acid. Once cooled, the insoluble residue by filtering was separated by a filter without Ashes. The filtrate was carried to a volume of 50 mL. From this acid extract, calcium and magnesium were determined by atomic absorption spectroscopy and sodium and potassium by flame photometry.

III. RESULTS

3.1 Background

The first experimental test, consisting of a structure of 3 levels of height with an artificial groundwater layer of seawater, presented as main objective to have a soil with a drainage capacity related to the depth to the groundwater.

The first plant species used was chard (Beta vulgaris var. Cycle). It was observed that the growth of this species varied considerably from one level to another. But it not only changed the size of the plant (something acceptable because of overexposure to sea water at the lower levels) but also its flavour.

By checking that the chard was growing in all three levels, other species such as arugula, tomato, cabbage, pepper, basil or lettuce were started to be tested.

3.2 Container construction

3.2.1 Evolution of the land

Figure 9 shows the development of chard, dandelion and cherry tomatoes in containers that were exposed to rain. Obviously, the growth was more pronounced in the container with substrate with high content of organic matter.

(a) **(b)**

FIGURE 9. Influence of the chemical composition of the substrate on the growth of plants after 23 days of planting a) high organic content b) low organic matter content.

The follow-up of the experimental parameters gave the following results:

Soil moisture

The percentage of humidity obtained was higher in the control vessel, which had been irrigated with network water. As far as the humidity determined in the two containers subjected to irrigation with seawater by capillarity is concerned, the container A, with high content in organic matter, presented a higher percentage compared with the container B, with little content in organic matter, especially in the initial rainy period (April), as it can be seen in Figure 10.

As the rain was waning and the ambient temperature was increasing, the difference between the two vessels was lower, with a tendency to equalize to values less than 10%.

In containers that were not subject to the influence of rain, it was found that the humidity of the control vessel was only slightly higher than that of the vessels that received water supply by capillarity. This behaviour, initially not expected, was attributed to different factors, highlighting the composition of the substrate and the fact of not having the influence of the weather.

However, during the development of this experiment, periodically, both the irrigation with fresh water in the control vessel and the seawater in the containers subjected to capillary irrigation with seawater were limited. In this way, the ability to recover moisture depending on the composition of the substrate was revealed.

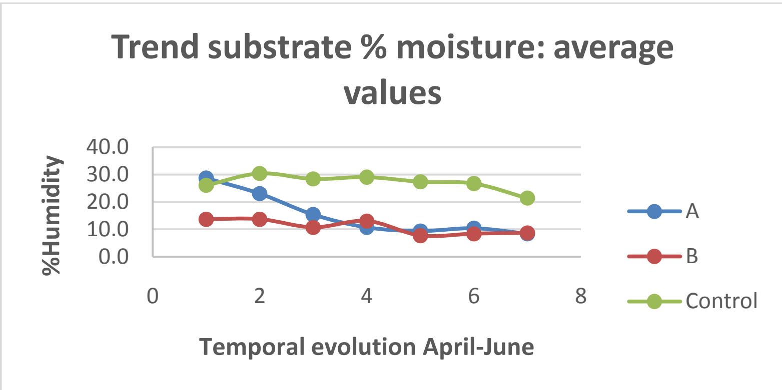


FIGURE 10. Temporal evolution of humidity percentage: A) container with vegetable compost B) container without vegetable compost. Control) control container.

As it can be seen in Figure 11, the value of the moisture percentage experienced a decrease in the three containers. The control vessel and the vessel with a sandstone layer of 25% of the useful height of the vessel presented to each other a much more synchronized behaviour than the vessel with a sandstone layer of 75% of the useful height of the vessel. After an initial period with different alternatives, both substrates ended up converging towards the end of the experience towards values of 30% of humidity. It should be noted that these percentages trebled those obtained in the experiences exposed to the weather.

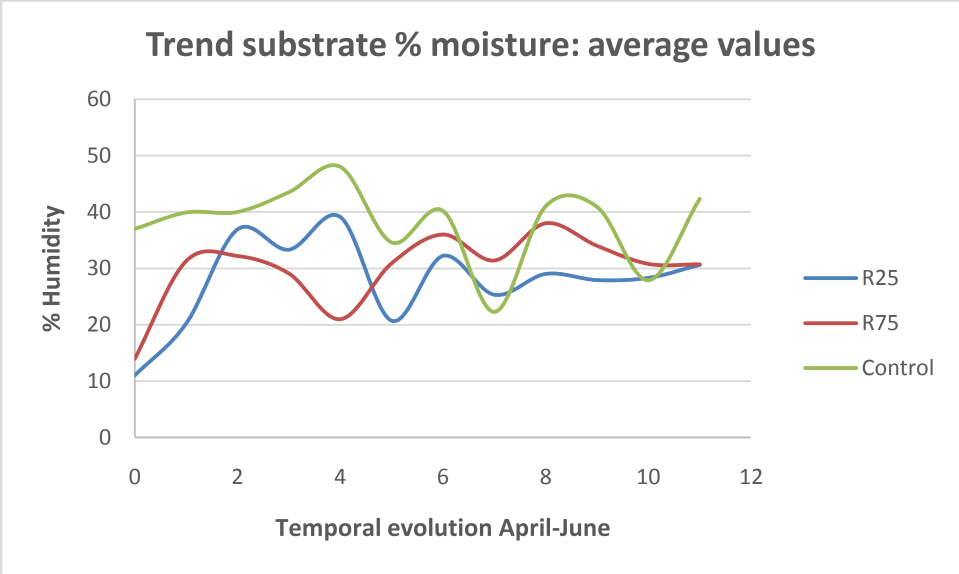


FIGURE 11. Temporal evolution of the humidity percentage: R25) container with a sandstone layer of 25% of the useful height. R75) container with a sandstone layer of 75% of the useful height. Control) control vessel.

3.2.1.1 Conductivity of substrates

In the substrates that had the influence of the weather, the results obtained in the percentage of humidity were complemented by those of the conductivity, since the values obtained in the container B were, systematically, higher than those obtained in container A, as shown in Figure 12.

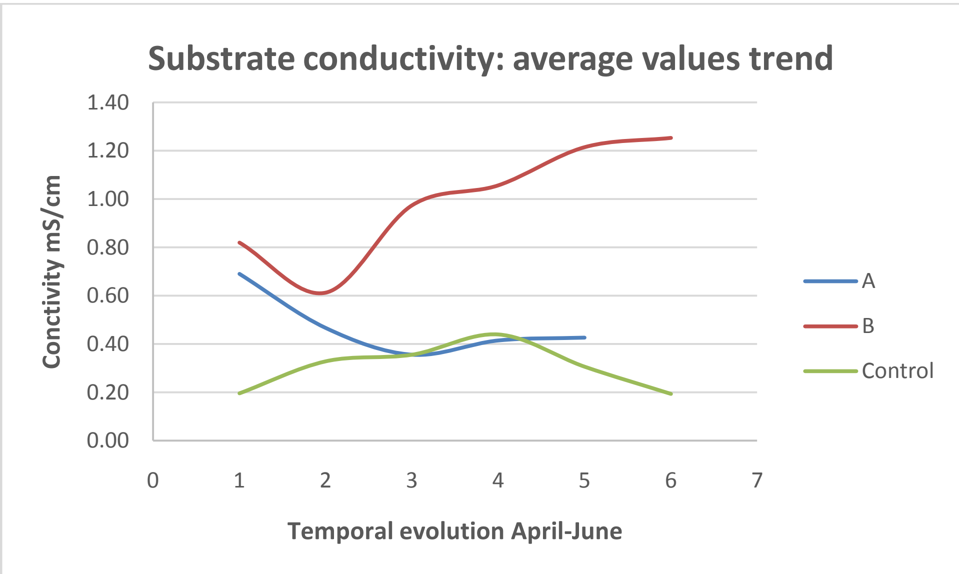


FIGURE 12. Temporal evolution of the substrate conductivity: A) container with vegetable compost. B) Container without vegetable compost. Control) control container.

This behaviour was attributed to the contribution in inorganic compounds of the selected substrate. Only in the case of strong rainfall, greater than 5 L/m2, this parameter provided anomalous results, as a result of the leaching effect of the fallen water on the ground. As far as the control vessel is concerned, freshwater irrigation caused the value of the conductivity to show a tendency lower than that of the selected substrates.

On the other hand, in the substrates those were not subjected to the inclement weather, the values of the conductivity showed a significantly lower dispersion (Figure 13). On the contrary, the experimental values of the control vessel were lower, and, in addition, they experienced a greater dispersion, attributable to manual irrigation with fresh water.

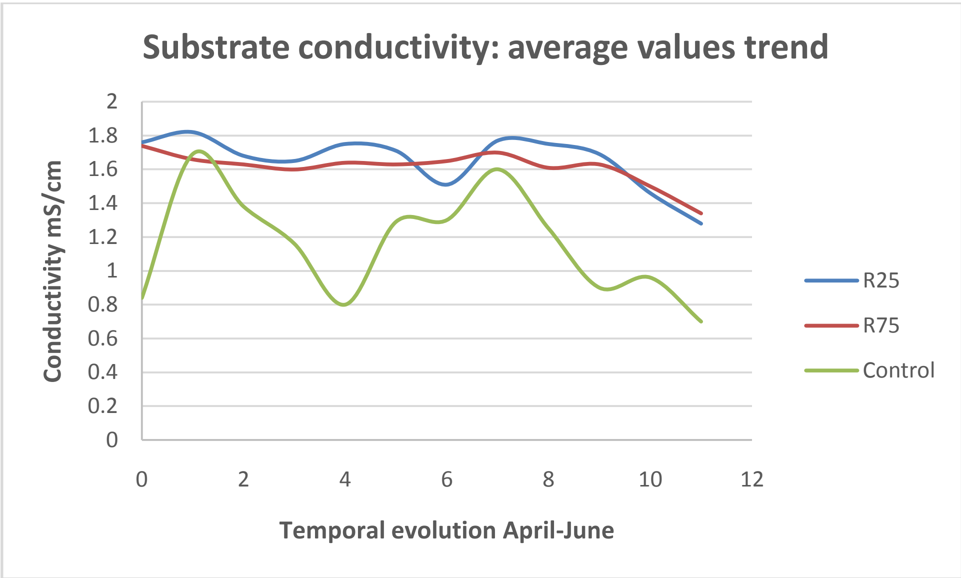


FIGURE 13. Temporal evolution of the conductivity of the: R25) container with a layer of sandstone of 25% of the useful height. R75) container with a layer of sandstone of 75% of the useful height. Control) control vessel.

3.2.2 Evolution of vegetables

First of all, the samples were prepared. In the case of lettuce, samples were taken from the aerial part of the plant and from the roots. Table 2 shows the results of moisture and content in organic matter.

As far as the percentage of humidity is concerned, the lettuce leaf developed in the control vessel showed a slightly higher value than the lettuce leaves developed in vessels with capillary irrigation. This result was consistent with the percentage of humidity determined at 20 cm depth in the different containers.

TABLE 2
MOISTURE PERCENTAGE IN FRESHLY PICKED LETTUCE AND PERCENTAGE OF ORGANIC MATTER AND AVERAGE PH VALUES IN ASHES

Code	% Humidity	% Organic material	pH
Leaf L75	89,96 ± 1,95	72,60 ± 0,50	10,3
Leaf L25	89.93 ± 0,75	64,86 ± 0,65	9,6
Leaf LC	94,23 ± 1,15	67,78 ± 0,45	10,3
Roots L75	67,65 ± 0,88	65,28 ± 1,10	7,9
Roots L25	80.97 ± 1,05	75,29 ± 1,25	9,9
Roots LC	82,97 ± 0,95	84,98 ± 0,95	10,9

L75: lettuce developed in the bowl with 75% useful height of sandstone
L25: lettuce developed in the bowl with 25% useful height of sandstone
LC: lettuce developed in the control container

The percentage of humidity determined in the roots of the plant, the control vessel showed a slightly higher value than the plant developed in the vessel with a layer of sandstone coinciding with 25% of the vessel's useful height. On the contrary, the roots that were developed in the vessel with a layer of sandstone coinciding with the 75% of the vessel's useful height showed a significantly lower value.

On the other hand, the percentage of organic matter determined in lettuce leaves showed a central value corresponding to the plant developed in the control vessel. Paradoxically, the value corresponding to the plant developed in the vessel with a useful height of 75% of sandstone showed the highest percentage. However, when the results were considered for the roots, the control value exceeded by far the other two values.

All the ashes, after being treated with distilled water for 10 minutes, showed alkaline pH values. If the specimen block corresponding to the leaves is considered, these values oscillated between 9.6 and 10.3 pH units. When the block corresponding to the samples for the roots was considered, a greater dispersion was observed, between 7.9 and 10.9 pH units, corresponding to the value of 7.9 to the sample developed in the vessel with a 75% of useful height of sandstone and that of 10.9 to the control vessel.

Table 3 shows the results corresponding to the sherry tomato. Results were obtained from roots, stems, leaves, and fruits. The lower percentage of humidity was determined in roots, being the control vessel where the lowest of the values were determined, whereas in the containers subjected to the capillarity regime with seawater, practically identical values were obtained.

The other three parts considered (stem, leaf and fruit) showed values of the same degree of magnitude, significantly higher than those determined in the roots.

When the values of organic matter were determined, the higher percentages were determined in the roots and, unlike the experience with the values of the humidity, the percentages in organic matter were not of the same order of magnitude in the stems, leaves and fruits.

The lower percentages of organic matter were determined in the stem. While the lesser of them was the one corresponding to the tomato developed in the container with a 25% useful height of sandstone, the other two values were, practically, equivalent.

This situation was repeated with the results determined in the leaves. However, on this occasion the other two results were very different from each other, presenting the highest value the control vessel.

Finally, the values determined in the fruit were very scattered among themselves, presenting the least of them in the control vessel.

As in the experience made with lettuce, all the ashes, after being treated with distilled water to boiling for 10 minutes, presented alkaline pH values. The vast majority of the values determined exceeded the 10 pH units.

TABLE 3
HUMIDITY PERCENTAGE IN FRESHLY HARVESTED TOMATO SHERRY AND PERCENTAGE OF ORGANIC MATTER AND AVERAGE PH VALUES IN ASHES

Code	% Humidity	% Organic material	pH
Roots T75	71,16± 1,75	86,03±0,95	9,7
Roots T25	71,99± 1,30	85,00±1,15	10,3
Roots TC	67,65± 1,55	85,74± 1,05	10,8
Stem T75	87,45± 0,85	66,92± 0,60	10,6
Stem T25	89,17± 0,75	54,54± 0,60	9,9
Stem TC	91,96± 0,70	65,83± 0,65	10,1
Leaf T75	85,53± 1,15	77,91± 0,70	8,6
Leaf T 25	86,14± 1,25	68,37± 0,55	9,1
Leaf TC	82,92± 1,20	84,75± 0,60	10,5
Fruit T75	88,83± 1,85	76,04± 0,50	10,0
Fruit T25	87,10± 1,90	68,80± 0,40	10,9
Fruit TC	89,28± 1,85	53,33± 0,55	10,6

T75: Tomato developed in the container with a 75% useful height of sandstone
T25: Tomato developed in the container with a 25% useful height of sandstone
TC: Tomato developed in the control container

3.3 Optimization of the material in contact with seawater

From the selected materials (sandstone, beach sand and compost), the different combinations included in Table 4 were initially tested.

TABLE 4
SELECTED SOIL COMPOSITIONS

	Composition
1	Thick sandstone 100%
2	Medium sandstone 100%
3	Thin sandstone 100%
4	Vegetable compost 100%
5	Sand beach 100%
6	90% Thick sandstone 10% Vegetable compost
7	90% Medium sandstone 10% Vegetable compost
8	90% Thin sandstone 10% Vegetable compost
9	90% Sand beach 10% Vegetable compost
10	50% Thick sandstone 50% Vegetable compost
11	50% Medium sandstone 50% Vegetable compost
12	50% Thin sandstone 50% Vegetable compost
13	50% Sand beach 50% Vegetable compost

The incorporation of compost originated instability in each mixture introduced inside the specimen, so that, with the passage of days the height of all the mixtures decreased significantly. This behaviour was attributed to the high humidity of the compost compared to sandstone and beach sand. Table 5 shows the percentage of humidity determined by weight loss at 110 ºC.

In a second experience it was decided to use the previously desiccated compost at 110 ºC until constant weight, analogous to how it had been done with the sandstone and beach sand. Even so, the experimentation with the compost was definitely left aside because, as much as it reduced its degree of humidity, the difficulties when compacting it in the tubes were very large due to the large amount of air that it contained and did not present the GA Warranties enough to obtain reproducible results.

TABLE 5
WEIGHT LOSS BY DRYING UP TO CONSTANT WEIGHT AT 110ºC

Material	Percentage
Thick sandstone	1,86%
Medium sandstone	2,76%
Thin sandstone	2,58%
Sand beach	Inappreciable
Vegetable compost	62,18%

Finally, coarse sandstone and beach sand were chosen as substrates to be used to systematically determine the height at which sea water rose and the variation of electrical conductivity attributable to this ascent.

Two series of 4 tubes were set, all of them, of the same diameter (57 ± 5 mm) and height (68 cm). In order to establish the influence of water's height contained in the containers, an experience was programmed in which half of the tubes were immersed 2 cm in the water and the other half 3cm,for a period of five days. This experience was made with coarse sandstone and beach sand. Table 6 shows the results obtained with coarse sandstone after the first 5 days, in the 68 cm high specimens.

TABLE 6
HEIGHT OF SEAWATER INSIDE THE SPECIMENS OF 68 CM IN FIVE DAYS

Day	Initial level of water (cm)	Gross height (cm)	Net height (cm)	Ascent speed (cm/day)
3	2	15,9	13,9	4,6
	3	16,6	13,7	4,6
4	2	16,6	14,6	3,7
	3	17,8	14,9	3,7
5	2	17,9	15,9	3,2
	3	18,9	16,0	3,2

After these 5 days, only in the container in which the specimens were submerged 2 cm in seawater, the same initial volume of seawater was added.

Table 7 shows the results obtained with coarse sandstone from the fifth day in the 68 cm high specimens.

TABLE 7
EIGHT OF THE SEAWATER INSIDE SANDSTONE'S SPECIMENS OF 68 CM FROM THE FIFTH DAY

Day	Initial level of water (cm)	Gross height (cm)	Net height (cm)	Ascent speed (cm/day)
5	3,4	18,3	----	-----
	1	18,6	----	-----
7	3,4	20,3	2	1
	1	20,3	1,7	0,8
10	3,4	22,6	4,3	0,9
	1	22,5	3,9	0,8
12	3,4	24,0	5,7	0,8
	1	23,8	5,2	0,7
17	3,4	25,7	7,4	0,6
	1	25,7	7,1	0,6
20	3,4	28,6	10,3	0,7
	1	28,1	9,5	0,6

The results obtained in this experience showed the null influence of the different level of sea water inside the container.

The tested levels were 3 and 4 cm in the experiment made with 28 cm high specimens. The experimental results obtained for five days are shown in table 8.

TABLE 8
HEIGHT REACHED BY THE MARINE WATER INSIDE THE TEST PIECES OF 28 CM

Day	Initial level of water (cm)	Gross height (cm)	Net height (cm)	Ascent speed (cm/day)
3	3	18,1	15,3	5,1
	4	18,6	14,6	4,8
4	3	19,2	16,3	4,1
	4	19,7	15,7	3,9
5	3	20,5	17,6	3,5
	4	20,9	16,8	3,4

On this occasion, the net values of the height reached by the seawater inside the test tube were slightly higher than those of the experience carried out with 68 cm high specimens (see table 6). However, when the average velocity values were considered, a convergence was found in this parameter on the fifth day.

Five days later, in one container the specimens were submerged 3cm in seawater, the same volume with which the experience began, while in the other container no volume of seawater was added.

When the control of seawater height reached inside the specimens was retaken, the reference values were 20.4 and 21.0 cm, respectively. Table 9 shows the results obtained with coarse sandstone from the fifth day in the 68 cm high specimens.

TABLE 9
HEIGHT OF SEAWATER INSIDE THE TEST PIECES OF 28 CM FROM THE FIFTH DAY

Day	Initial level of water (cm)	Gross height (cm)	Net height (cm)	Ascent speed (cm/day)
5	3,4	20,4	----	-----
	1	21,0	----	-----
7	3,4	22,8	2,4	1,2
	1	23,1	2,9	1,4
10	3,4	25,7	5,3	1,1
	1	25,6	5,6	1,1
12	3,4	26,9	6,5	0,9
	1	26,6	5,6	0,8
17	3,4	25,7	7,4	0,6
	1	25,7	7,1	0,6
20	3,4	29,5	9,1	0,6
	1	28,4	7,4	0,5

Both experiences showed a convergence in the values of the average velocity of ascension of seawater by the inside of the specimens, regardless of their height, towards values of the order of 0.6 (cm/day), as it can be seen in Figure 14.

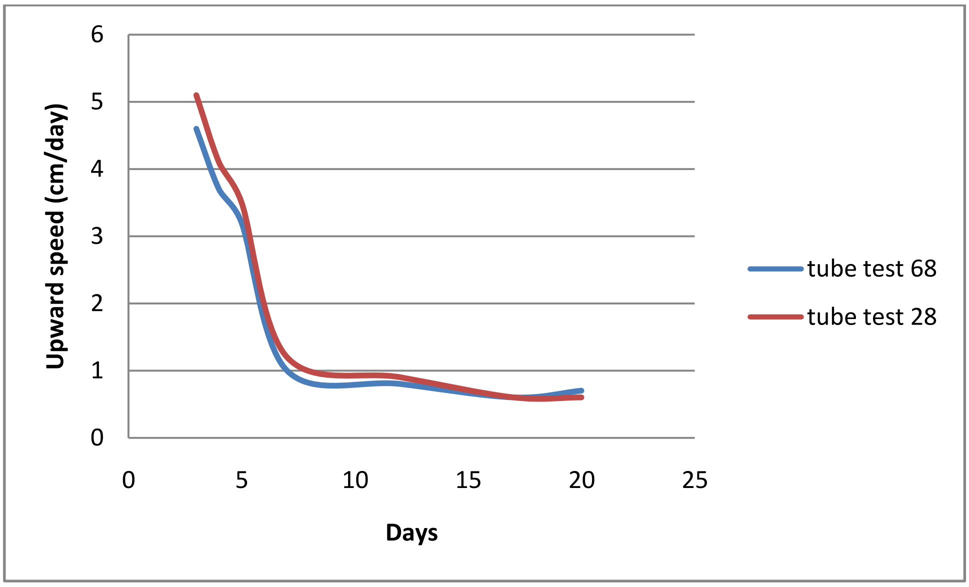


FIGURE 14. Temporal evolution of the ascending velocity of seawater inside the specimens

When the experience with beach sand was repeated, the ascent of the seawater inside the specimens was much smaller, compared to the results obtained with the sand stone. Such is the case that in 35 days the ascent observed in both types of specimens was 9.3 cm which is equivalent to an upward velocity of 0.26 cm/day.

This difference between the values of the ascending velocity was justified by the different particle size of both substrates. Thus, in the coarse sandstone used, the particles of more than 2 mm diameter predominate, while in the sand of the beach the predominant particle diameter was less than 1 mm (see table 1). This difference in the predominant size of the particles caused the degree of compaction to be significantly higher in the beach sand, so that the capillary capacity of this substrate decreased.

On the other hand, samples were taken from inside the specimens at different levels. Experimentally, it was necessary to gradually empty each specimen from the upper part and take the corresponding aliquots at the previously determined heights.

As a reference point, the maximum height delimited by seawater was considered within the container where the specimens were inserted. From that height, the different levels were set. Table 10 shows the experimental values that were considered for the specimens of 68 and 28 cm of height, as well as the corresponding values of the conductivity.

The values of the conductivity were decreased as the aliquots were taken at a higher height than the sea water level in the vessel, with convergent values starting at 17 cm height.

TABLE 10
CONDUCTIVITY VALUES VS HEIGHT REACHED BY SEAWATER INSIDE THE TEST TUBE

Test tube 68 cm height		Test tube 28 cm height	
Height above seawater level (cm)	Conductivity (mS/cm)	Height above seawater level (cm)	Conductivity (mS/cm)
3,6	1,49	0,7	1,99
8,1	0,94	6,7	1,18
12,6	0,76	12,7	0,82
17,1	0,61	18,7	0,63

3.4 Experiences with the Tlaloc device

In order to determine how the different variables that were contemplated in the experiment affected: irrigation water, substrate and filter height, and to obtain a first approximation of the useful life of the product, the study was focused from two slopes.

First, it was determined how it affects the irrigation with seawater on the different quality parameters of the chard as they are: moisture, mineral matter, Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} content, ascorbic acid, colour, weight, height and leaf width. Secondly, it was determined how some of these quality parameters evolve over 12 days in the product preserved at 4 ± 1 ºC.

3.4.1 Characteristics of the irrigation water used.

Table 10 shows the characteristics of the two types of water used, the control (water network) and seawater, both obtained in the locality of Badalona.

As expected, seawater presented a very high mineral content, which resulted in that its value of conductivity was of the order of 40 times higher than that of the net water, being the predominant anions chlorides and sulphates while the cations Majoritarian were sodium and magnesium. As far as the pH values are concerned, they were very similar around the neutral pH.

TABLE 10
CHARACTERISTICS OF IRRIGATION WATERS USED IN THE CULTIVATION OF SWISS CHARD

Badalona seawater									
pH: 7,03									
Conductivity: 39,8 mS/cm									
Ions (mg/L)	NH_4^+	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NO_2^-	NO_3^-
	< 10	260	10060	435	1280	15882	2305	< 10	60
Badalona fresh water									
pH: 7,31									
Conductivity: 985 µS/cm									
Ions (mg/L)	NH_4^+	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NO_2^-	NO_3^-
	< 1	13	99	87	23	139	88	< 1	7

3.4.2 Effect of seawater on different quality parameters

3.4.2.1 Effect of filter height (6 or 20 cm) on moisture content and mineral matter

With regard to the effects of the height of the filter used, it was observed that those samples with less filter height (6cm), regardless of the material used (sand beach or sandstone), showed a tendency to retain more moisture.

This behaviour was attributed to the largest amount of compost contained in the TLALOC device. In this sense, he highlighted the control device (consisting exclusively of vegetable compost) as the sample of chard with higher moisture content (see table 11). On the contrary, this trend was reversed when the percentage was considered in mineral matter, the sample of control being the one that presented the least of the experimental values. In fact, all samples irrigated with seawater show a mineral content between 4 and 12% higher than the control sample, depending on the treatment.

TABLE 11
PERCENTAGE OF MOISTURE AND MINERAL MATTER ON THE DAY OF HARVEST (D.0) AND EVOLUTION OF HUMIDITY DURING A PERIOD OF 12 DAYS.

Treatments	Initial humidity (%)	Mineral matter (%)	Humidity day 2	Humidity day 6	Humidity day 8	Humidity day 12
A1 (6 cm)	91,05 ± 2,05	35,59 ± 0,55	92,10 ±1,85	92,21 ± 1,60	91,9 ± 1,35	91,67 ± 1,20
S1 (6 cm)	90,82 ± 1,95	39,09 ± 0,65	91,78 ± 1,95	90,42 ± 1,50	90,83 ± 1,55	91,16 ± 1,10
A2(20 cm)	89,22 ± 1,70	43,53 ± 0,45	88,48 ± 1,50	88,04 ± 1,75	88,09 ± 1,50	88,27 ± 1,25
S2(20 cm)	89,99 ± 1,75	39,31 ±0,55	89,05 ± 1,80	89,65 ± 1,65	88,78 ± 1,40	88,39 ± 1,30
Control	94,37 ± 2,15	31,28 ± 0,60	93,13 ± 1,90	93,91 ± 1,45	93,89 ± 1,50	93,83 ± 1,15

A1/S1 Containers with a 6 cm high sand and sand beach filter, respectively
A2/S2 Containers with a 20 cm high sand and sand beach filter, respectively

When the samples of chard kept inside a refrigerator were treated at 4 ± 1 ºC up to a maximum of 12 days, the humidity of the control sample showed higher values than the rest of the samples considered (see Figure 15).

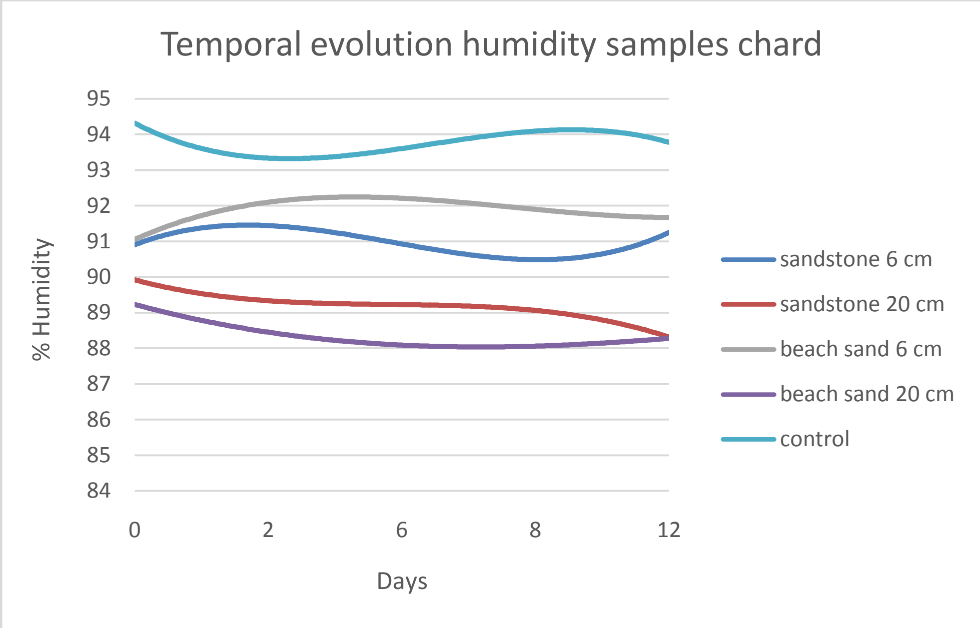


FIGURE 15. Temporal evolution of humidity in chard samples preserved in the fridge

The samples with less filter height (6cm) maintained the tendency to present a higher moisture percentage to the samples with higher filter height (20 cm), regardless of the type of filter considered (sandstone or beach sand). The samples with a 6 cm filter converged, at the end of this time period, towards humidity values of 91% and the samples with a filter of 20 cm did it towards values of 88%, while the control sample presented a value of 94%. This showed the influence of the filter height used: At higher altitude, lower moisture content.

As far as the concentration of alkaline and alkaline metals is concerned, it stands out the low magnesium content in all the treatments. However, when the values obtained with different filter heights (A1/A2) and (S1/S2) are compared, a tendency is observed to obtain higher concentrations with the 20 cm filters.

TABLE 12
CONCENTRATIONS OF ALKALINE AND ALKALINE EARTH METALS IN THE FRESHLY COLLECTED SAMPLES, AFTER BEING DRIED AND CALCINED

Treatment	Na^+ (g/Kg DS)	K^+ (g/Kg DS)	Ca^{2+} (g/Kg DS)	Mg^{2+} (g/Kg DS)
A1 (6 cm)	21,24 ± 0,25	30,41 ± 0,30	13,73 ± 0,15	0,33 ± 0,07
S1 (6 cm)	37,87 ± 0,20	42,03 ± 0,35	26,50 ± 0,25	0,77 ± 0,05
A2(20 cm)	48,90 ± 0,30	41,86 ± 0,30	26,46 ± 0,20	0,76 ± 0,04
S2(20 cm)	55,78 ± 0,25	37,05 ± 0,25	30,91 ± 0,20	0,84 ± 0,06
Control	29,16 ± 0,20	50,82 ± 0,30	21,93 ± 0,25	0,71 ± 0,08

A1/S1 Containers with a 6 cm high sand and sand beach filter, respectively
A2/S2 Containers with a 20 cm high sand and sand beach filter, respectively
DS, Dry sample

When the values obtained in the control vessel were considered, a very high value was observed in the case of potassium, a fact that was attributed to the composition of the compost plant (NPK 18-10-20).

3.4.2.2 Effect of filter height (6 or 20 cm) on ascorbic acid content

The ascorbic acid content in the samples of freshly collected chard showed a different behaviour depending on the height of the filter, regardless of whether it was sandstone or beach sand. Thus, samples from vessels with less filter height (6cm) showed a lower ascorbic acid content than those from a higher-height filter (20 cm). After an irregular evolution during the first 6 days, with the exception of the samples from the containers with a filter of 6 cm of beach sand, the whole of the samples presented convergent values towards 11 mg of ascorbic acid/100 grams Initials of Chard at 12 days. Figure 16 shows this behaviour graphically.

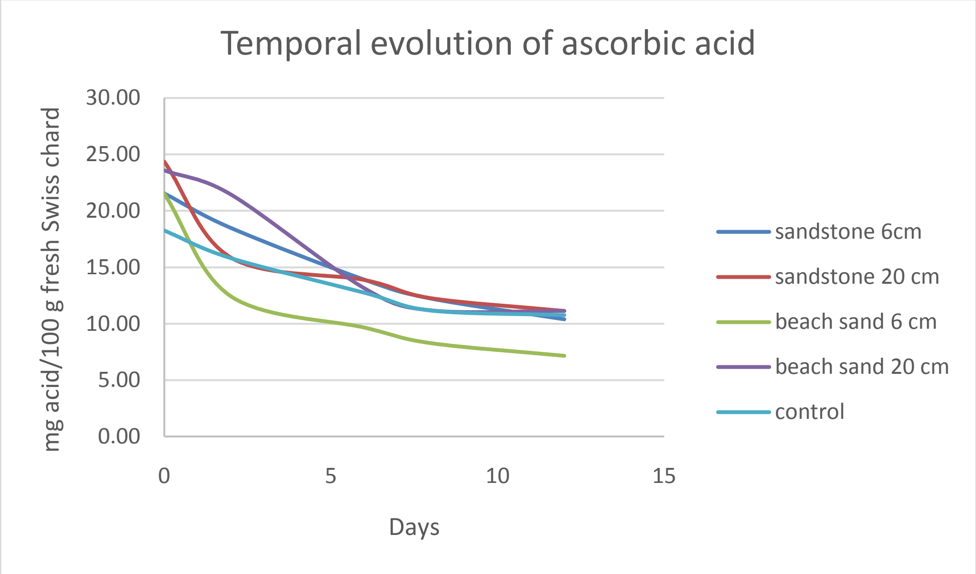


FIGURE 16. Temporal evolution of ascorbic acid during 12 days

3.4.2.3 Effect of filter height (6 or 20 cm) on the weight, height and width of the chard

Samples from vessels with less filter height (6cm) showed a significantly higher weight than the samples coming with a higher filter height (20 cm). Among them, the ones from a sandstone filter presented more weight than those coming from a beach sand filter.

Table 13 shows the relation of weight, height and width of the chard according to the treatment to which they had been subjected.

TABLE 13
AVERAGE VALUES OF WEIGHT, HEIGHT AND WIDTH OF THE FRESHLY HARVESTED SWISS CHARD

Treatment	n	Weight (g)	Height (cm)	Width (cm)
A1 (6 cm)	32	93,08 ± 18,72	16,86 ± 2,11	11,78 ± 1,99
S1 (6 cm)	32	113,03 ± 10,95	17,73 ± 1,71	12,13 ± 2,31
A2(20 cm)	32	56,38 ± 8,86	14,48 ± 1,79	9,58 ± 2,20
S2(20 cm)	32	41,77 ± 12,75	12,30 ± 2,99	8,56 ± 2,26
Control	32	99,47 ± 47,14	17,00 ± 3,10	10,25 ± 1,91

A1/S1 Containers with a 6 cm high sand and sand beach filter, respectively
A2/S2 Containers with a 20 cm high sand and sand beach filter, respectively

3.4.2.4 Effect of filter height (6 or 20 cm) on the colour

From the experimental values of the parameters determined with the colorimeter KONICA MINOLTA CR-400,it was proceeded to calculate the corresponding colour index (I.C.).

The results obtained are shown in table 14. The values of IC obtained allowed cataloguing the chards with a bluish-green colour. Samples from vessels with less filter height (6cm) were closest to the colour of the control sample, especially after being collected and after 6 days.

TABLE 14
EVOLUTION OF THE COLOUR INDEX (I.C.) OF CHARD FOR A PERIOD OF 12 DAYS

Treatment	Initial IC	6th day IC	12th day IC
A1 (6 cm)	-36,93 ± 2,25	-36,08 ± 0,85	-34,29 ± 3,88
S1 (6 cm)	-37,21 ± 3,54	-36,75 ± 2,76	-34,11 ± 3,93
A2(20 cm)	-35,97 ± 4,62	-36,97 ± 2,54	-36,73 ± 3,08
S2(20 cm)	-35,33 ± 4,66	-38,23 ± 3,46	-34,68 ± 2,99
Control	-38,30 ± 1,29	-35,36 ± 1,84	-36,35 ± 1,33

A1/S1 Containers with a 6 cm high sand and sand beach filter, respectively
A2/S2 Containers with a 20 cm high sand and sand beach filter, respectively

IV. DISCUSSION

Current patterns of development and production are unsustainable because they lead to overexploitation of aquifers and rivers, environmental degradation and loss of coastal and indoor wetlands (Marcellesi 2012). In the last fifty years the world irrigated area has doubled and water withdrawals for agriculture have increased (Siebert *et al* 2010).

Life in rural areas is in fact facing very serious problems in practically all countries. The scarcity of good quality water resources is becoming an important issue in arid and semiarid areas. For this reason, the availability of water resources of marginal quality, such as drainage water, saline groundwater and treated wastewater, has become an increasingly considered option (Martínez 1999).

Different studies indicate that brackish water can be used successfully for the production of irrigated crops (Al-Karaki 2006; Niu *et al.* 2010; Jiang *et al.* 2012; Malash *et al.* 2012; Singh & Panda 2012). However, the negative effects on crops may occur from the use of saline water due to the accumulation of salt in the soil (Rengasamy, 2010; Wan *et al*. 2010; Huang *et al*. 2011; Wang *et al*. 2015), especially in regions of limited rainfall (400 mm/year). The extension of the salt accumulation in the different layers of the soil is affected by the specific management of irrigation and local climatic conditions. The dynamics of water in the soil, the structural stability of soil, the solubility of compounds in relation to pH and the movement of nutrients and water play a vital role in the selection and development of salinity tolerant plants.

The incorporation of desalinated seawater into irrigated areas is another alternative that has been booming in recent decades. At the global scale of the main experiences of agricultural irrigation with desalinated water shows that, in many countries with arid or semiarid climate, and that also have a highly technical agriculture, the desalination of brackish waters It represents an additional source of water (ANZECC & ARMCANZ, 2000).

The main advantage of desalination of brackish or marine water is its condition as an inexhaustible water resource and not subject to climatic variations, so strategically it is ideal to systematically increase the availability of water resources for agricultural irrigation in deficit areas. However, only the most technical crops and with higher economic margins can withstand the costs of desalinated water (Martínez & Martín 2014). Starting a desalination plant implies an investment and very high maintenance costs, in addition to a considerable energy consumption that is mainly covered by the use of fossil fuels, with the environmental damage that this involves.

The effect of soil also plays an important role in those soils affected by salinity. Soils also play an important role, especially in those affected by salinity. If a soil is saline, but it is not permeable there will not be enough drainage and therefore there will be a greater accumulation of salts, usually in the area of the roots. For this reason, it is very important to take care of the drainage and aeration of soils affected by salinity (Maas, 1993).

At the time of irrigation, with the traditional irrigation system, water content in soil is maximum, while the concentration of soluble salts is minimal. While water is lost by evaporation and by perspiration, the content of salts around the plant increases. It is for that reason that the more salt content water contains, the more frequent irrigation should be to minimise the impact of water stress on the crop. However, an excess of watering could cause a lack of air in the soil, particularly with those very fine particle soils with little porous space (Maas & Hoffman, 1977).

The tolerance of crops to salinity is expressed as the decrease in the yield of a crop in which a saline concentration has been applied in the root zone, compared to the yield of a crop without the application of a saline solution. (Maas and Hoffman, 1977). This tolerance and the effect that salinity produces on the plant depend on the species and other environmental conditions. (Shannnon & Grieve, 1999).

Temperature, relative humidity, environmental pollution significantly affects the plant's response to salinity. Most crops tolerate soil salinity better when there is a cooler, wetter environment. The combination of environmental factors such as high temperatures (summer temperatures), wind, low humidity ($< 50\%$) Either the drought is more damaging and have a more negative effect on the plant than the salinity itself (Blankendaal *et al.* 1972; Maas, 1993).

The first effects of salinity experienced by the plant are those caused by the osmotic effect. Roots are reduced to length and mass, but not in thickness. The osmotic effect of salinity contributes to reduce the growth rate, changing the colour of the leaves and slowing the normal growth rate. The ionic effects are usually manifested in leaves and meristems. Thus, large amounts of Na^+ and Cl^- accumulate in leaves causing burns.

The symptoms due to lack of nutrients caused by salinity are similar to those suffered by plants irrigated with fresh water, but with lack of nutrients in the substrate. However, not all effects are negative. In spinach, for example, salinity can have a positive effect on disease resistance. On the other hand, the sugar content in the carrot increases with the presence of salts while the starch content decreases in the potato (Maas & Hoffman, 1977; Shannon & Grieve, 1999).

High salinity in soil's pores affect plants in several ways. First, the osmotic potential of the soil experiences a descent; This makes it more difficult for the plant to obtain water from the ground, since the plant should decrease the osmotic potential of its roots below the osmotic potential of the soil in order to obtain water. Second, the ions from the salt that enter the water inside the plant can also cause physiological damage because elevated Na^+ levels can give high toxicity by the plant(Munns *et al.* 2006). This large amount of Na^+ in soil's pores increase competition with the K^+ ions, mineral that is essential for the plant, since the two ions use the same channels to enter inside, giving rise to a lower absorption of K^+ and a deficit of this mine Ral. (De Vos *et al.* 2016).

On the other hand, there are antecedents in which seawater has been used without desalination as irrigation water for crops. Already in 1719, there are experiences carried out in the desert of San José de la Isla, where crops were irrigated with seawater by the Carmelite monks in the area where the convent was located (Esteban-Gómez 1968). Much more recent is the use of sandy and coastal sea-water belts for growing crops in India (Iyengar 1968).

It also highlights the contribution of Dr. Maynard Murray, who, in the mid-twentieth century, after many years devoted to medicine, concluded that the biggest cause of health problems came from a shortage of minerals in food, and this deficit came from the methods used in agriculture. By not having the cultivation of the minerals necessary for its correct growth and development (trace elements), these nutritional deficits passed both to the cattle and to the people, producing a set of alterations and imbalances in the organism (Murray 1976).

In the experiments carried out by CRESCA and the Aqua Maris foundation, it has been proven that, in the case of Swiss chards subjected to the most extreme conditions of the containers isolated from the weather, root growth of the roots has penetrated the growing medium and the filter zone, reaching the interface with the seawater in the last period of growth of the plant just before its collection.

To optimize the growth of other plant species, it is necessary to adapt and improve the composition and height of the filter zone.

V. CONCLUSIONS

The results obtained experimentally allow affirming that the direct use of brackish or marine water as irrigation fluid, as long as it is administered groundwater, is viable. However, this necessary condition is not enough. It is necessary to have a substrate as a filter with certain characteristics (composition and particle size) that allow reducing the saline content and maintaining the humidity at a sufficient height so that the roots of the cultivated vegetables can absorb enough water and nutrients without reaching toxicity limits.

In addition, it is necessary to keep in mind the climatic influence (rain, wind, temperature...) As long as this experience is not carried out inside a greenhouse where the environmental conditions can be regulated.

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